Mid-term long baseline electron neutrino appearance experiment: 5kton Liquid Argon TPC at Ash River

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Long baseline neutrino appearance experiments are sensitive to $\sin^2 2\theta_{13}$, the mass hierarchy (if the baseline permits), and CP Violation in the neutrino sector. The worldwide neutrino program is focused on these long baseline experiments with measurements anticipated at T2K, in Europe with the proposed MODULAR experiment, and in the US with the NOνA program. NOνA, with a 20 kton totally active liquid scintillator, segmented detector will be sensitive to $\sin^2 2\theta_{13}$ with minimal sensitivity to the mass hierarchy. To improve upon the sensitivity to $\sin^2 2\theta_{13}$ and gain sensitivity to the mass hierarchy, a signature of the US program, a 5 kton Liquid Argon Time Projection Chamber (LArTPC) sited at Ash River is proposed here.

With fine-grained tracking and total absorption calorimetry, LArTPCs are ideal for $\sim$1 GeV neutrino physics. Specifically, LArTPCs are nearly background free from muon neutrino mis-IDs including those from neutral current pion interactions. This coupled with an 80% electron neutrino efficiency makes these detectors $\sim$4 times more sensitive than conventional detectors. There are a number of designs for scaling these detectors to the 50-100kton scale necessary for next generation long baseline experiments. However, a mid-term program with a 5kton far detector coupled with a near detector program has a strong physics program and will advance the R&D effort towards the massive scale. This program will build upon what is learned via R&D by the microBooNE LArTPC experiment, addressing the MiniBooNE low energy excess.

The 5kton LArTPC, combined with the NOνA experiment will improve upon the sensitivity to $\sin^2 2\theta_{13}$ as shown in Figure 1 and described in more detail in reference [1]. A larger mass LArTPC or equivalent increase in beam exposure, will allow for sensitivity to the mass hierarchy, as shown in Figure 2. A $\sim$ 60 ton LArTPC detector sited near the NOνA near detector can serve both as a near detector for this program and a fine-grained detector for the NOνA experiment. Specifically, a $\sim$60 ton active volume ($\sim$ 20 ton fiducial volume) near detector will collect $\sim$10k electron neutrino interactions during the NOνA run for systematic error studies. This near detector would also be ideal for neutrino cross section measurements. An aggressive, technically driven schedule points to design and construction for this near and far detector program in the next $\sim$5-7 years with data taking to begin in 2013-2015.

The US neutrino program has potential to grow beyond the already successful neutrino experiments at Fermilab. A 5kton LArTPC experiment building on the existing NOνA program and taking advantage of the NuMI neutrino beam can keep the US in the lead in long baseline neutrino physics in sensitivity to $\sin^2 2\theta_{13}$ and sensitivity to the mass hierarchy in the mid-term, en route to the next generation long baseline neutrino program beyond this.

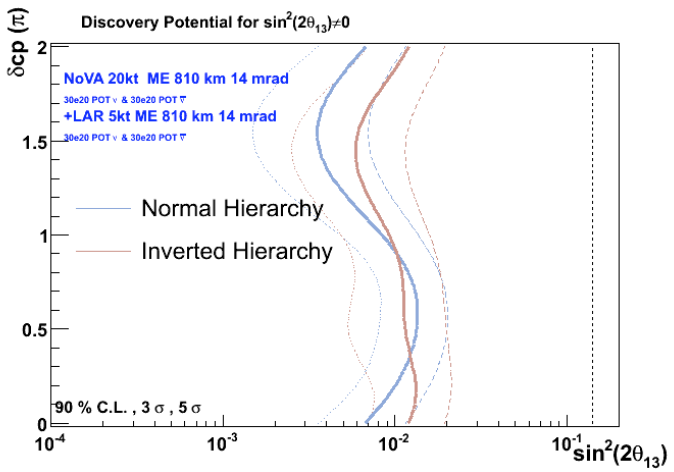

Figure 1: Sensitivity to $\sin^2 2\theta_{13}$ for NOνA plus a 5 kton LArTPC sited at Ash River

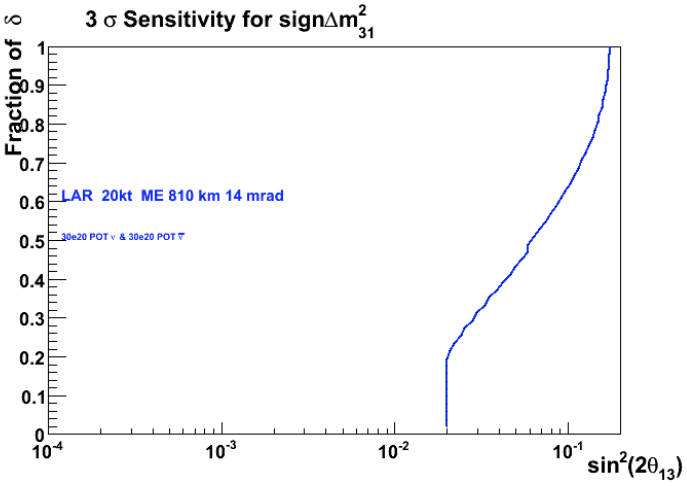

Figure 2: Sensitivity to the mass hierarchy for a 20 kton LArTPC, or a 5kton LArTPC with x 4 increased exposure.

References

[1] V. Barger *et al.*, "Report of the US long baseline neutrino experiment study," arXiv:0705.4396 [hep-ph].